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ACOUSTICS:

SUGGESTIONS IN BEHALF OF AN UNPOPULAR SUBJECT

By LOUIS C. ELSON

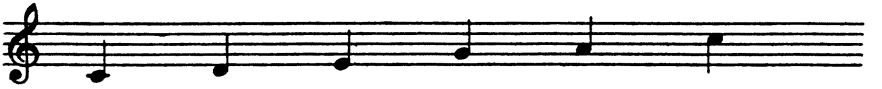
WHEN the wonderful advance of the musical curriculum in America is taken into consideration, it is astonishing how little attention is given to the foundation subject of Acoustics. Many conservatories which insist upon Musical History, Solfeggio, Harmonic Analysis, and many other accessory studies, are entirely innocent of any attempts in the direction of the physical basis of Sound and Music, and make no effort to include the topic in their course. Many an advanced musician while stating facts in instrumentation to his class is yet unable to explain the causes of these facts. It is the object of this article to indicate a few of the points in which acoustics may be a direct aid to the teacher.

There are many myths in music which the scientifically trained teacher will at once proceed to demolish. In the first place, musical progressions have, as far as is yet discovered, no real foundation in Nature. It is true that Nature gives us a chord, whenever any tone is sounded, yet she gives us no connection whatever of one chord with another, but presents these chords isolated and disconnected. It is possible that some of the most fiendish effects of ultra-modern music may seek an apology in the discords which the different chords of Nature make when sounding simultaneously, although in Nature they are sounded so faintly as to be inaudible to the average ear, while your true modern insists upon giving them fortissimo!

The teacher who has studied acoustics will be able to demonstrate to his pupils that music is an artificial product, of which the crude materials only are natural. Nature gives us regular vibration (in a tone), a simple chord (in the overtones), and a sense of rhythm. From these materials man evolves melody, connection of chords (harmony), uniting of melodies (counterpoint), and a certain arrangement of material in set progressions (scales or tonalities). He does this about as arbitrarily as he created languages from isolated and meaningless

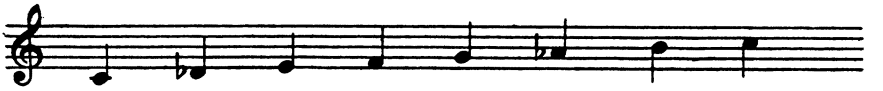
sounds. His scales differ about as much as languages differ. There is no such thing as a scale of nature. Here are a few of the arrangements of tones which constitute the scales of different races:

CHINESE OR OLD SCOTTISH

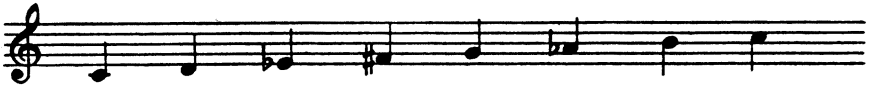


represented by the melodies of "Auld Lang Syne," "Bonnie Doon," etc.

BYZANTINE OR COPTIC

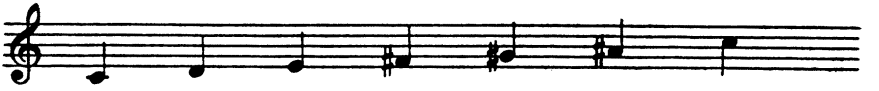


HUNGARIAN GYPSY



used by Paderewski in his opera "Manru."

SIAMESE



which brings us very close to M. Debussy and his school. And many other progressions might be cited, the Gregorian, the hexachordal, etc., while the Hindoo divides his scale into smaller intervals than can be represented in our notation, which, several Englishmen have assured us, although seemingly out-of-tune at first, become pleasing to the ear after it has heard them several times. The ever-changing style of music is but a proof that it is as much an artificial product as language itself.

Another myth which the acoustician may bowl over is the frequently made statement that animals are fond of music. We doubt whether a spider, a mouse, a horse or an elephant would be

moved in any great degree by Wagner, or Beethoven, or Bach, but a well-marked two-step, or a swingy march might have some effect. In short it is the *rhythm*, not the substance, of music which charms the lower creation, when it is not the steady vibration of tone itself. The music of the snake-charmers of India might be scientifically investigated with this thought in mind.

Another false idea in music could be taken up by the teacher who is versed in acoustics. The statement made by many musicians and composers that tone represents color has no tangible foundation. The half-informed ones here intrench themselves behind the incontrovertible fact that tone is vibration and color is vibration also. The scientist must inform them that *everything* is vibration or motion of some sort, and that the vibrations of light are essentially different from those of tone. Also that the vibrations which produce the impression of color begin at about 460 trillions per second, while the vibrations of tone cease to be audible at about 38,000 per second, a gap which is almost too large for the human mind to span. Also that the human brain cannot perceive a single octave of color, while it can appreciate over eleven octaves of pitch. Also the rather important fact that, while many composers are very positive in their assertion that certain keys suggest certain colors, scarcely any two of them agree upon which color each key represents!

But it is not only in the spirit of destruction, or contradiction, that the musician should study his acoustics. Let us suppose the case of a violin teacher giving a pupil his first instruction in pizzicato-playing. He tells the student not to pick the string at the place where he has been in the habit of bowing, but further away from the bridge. The investigating student asks (and very properly)—"Why?" The teacher probably responds—"Because it gives a better tone"—and if the pupil put in another "Why?" he would probably remain unanswered.

The teacher should have the primitive knowledge that, with every tone that is sounded, there blend fainter, higher tones, which make the quality of the tone. He should know that while these occur in a certain fixed order they may differ greatly in power; that if they are too weak a "dead" or muddy tone is the result, while if they are too strong an irritating, aggressive, "tinpanny" tone is caused. He should understand that the plucked string gives the overtones more strongly than the bowed one; that the nearer to the centre we pluck the string, the more important overtones we destroy, thus making the tone duller; that we correct its over-brightness by this process.

Reasoning further upon the same line he will find that this is why the harper plucks his string in the centre; he may investigate a little further and find that the quality of the piano would greatly deteriorate if we put the hammers at some other proportion of the length of the string than just where they strike now. He might, by experiment, find out that if he plucked a string with his fingernail it would sound much brighter than if he used his finger-tip, and thus learn that plucking with a hard substance shivers the string into many small segments and produces many of the high overtones with inordinate power, thus making the irritating tone above mentioned. And thus he would be led to the subject of quality of tone and discover that in a rich and mellow tone the lower overtones must be rather full and the upper overtones faint, but clear.

Following out this line of inquiry he might discover that the delicacy of a tone depends upon just this preservation of the faint upper overtones, and this might reveal to him why his violin tone is "dead" in a damp and muggy hall, while it is delightful in a bright, clear atmosphere. The upper overtones are smothered out in the heavy air. This might reveal the cause of the almost celestial tone of the zither when heard on the high Alps. It might also reveal to him why he is never quite satisfied when he hears a great violinist's tone reproduced upon any of the records on any of the machines of gramophonic variety. The faint, high overtones cannot record themselves upon the wax, and the quality of the tone suffers because of this.

Still pursuing this train of thought he might understand why the mandolin is the brightest of all the stringed instruments, noting that it is plucked with a pick instead of by finger-tips. And now he might suddenly grasp the cause of the deep sound-box with which the instrument is provided. He would readily judge that it is the function of the gourd-shaped box to mellow a tone which might otherwise be far too bright, and he might verify this by listening to the modern invention which supplies the mandolin with a flat sound-box.

This subject would certainly lead him on to note other sound-boxes. He would then understand why the banjo, having not a sound-box, but merely a sounding-board, and that of calf or sheepskin instead of wood, must naturally be inferior to the guitar, in the quality of its tone.

And now, fairly launched upon the subject of sounding-boards and boxes, he would find another interesting point. Ascertaining that all sound (or tone) is merely vibration of the air,

he would note that a mere string, swinging to and fro, can move but an infinitesimal amount of atmosphere; therefore the stringed instrument must have its tone magnified exceedingly by the sounding-box, or, in the piano, by a large sounding-board. Should he pursue this interesting branch much further he would learn that Nature itself has made sounding-boards and boxes. There is a model sound-box in every human ear, and once a cloud (taking the right shape, angle and consistency), forming over Rio Janeiro, sent the sound of bells 200 miles out to sea.

He might study the materials of the sounding-board and find that certain varieties of pine-wood are best for this purpose, since their cells and fibres are almost of the character of a stretched string, and susceptible of far more vibration than those of other woods. He might also notice that a sound-box, be it ever so humble (as on a drum, for example) must needs have a sound-hole (sometimes two) to allow the air in the box to vibrate freely and not to form a cushion to prevent the free vibrations of the front board. He would find that even the sound-box in his ear had an excellent sound-hole in the Eustachian tube.

And now his investigations might lead him to other stringed instruments. If, perchance, he heard a viol d'amore he would be astonished to find that in addition to the seven strings above the finger-board there were seven tiny wires below it, never to be touched by the bow. In seeking to know the secret of these unplayed strings he would come upon the most beautiful law of Nature connected with music, the law of synchronism. The strings below the finger-board resound when their tone, or any of its overtones, is given by the string above. Whatever, in the universe, vibrates, will be set in motion if its own rate of vibration or that of any of its overtones is in the air and comes in contact with it.

This matter of contact leads our investigating violinist back to his instrument for a few new acoustical discoveries. He sees now that the bridge leads the vibrations of the strings to the sounding-board, and that the sound-post, under the bridge, leads these vibrations to the back-board, so that his whole sound-box is in vibration when he plays on the string above.

He now begins to broaden out his research into harmonics. He knows that if he touches a string lightly at any equal part of its length he produces one of the overtones alone. Possibly he also knows that this is caused by his dividing the string into several shorter strings of one half, one third, one fourth, etc., of its length (Paganini could divide his strings, made very thin, into twelfths)

and that this number of tiny strings is giving the high tone, all sounding together, and in unison.

But by and by it dawns upon him that it is not only strings that can subdivide in this way, but any column of air, and now he is on the road to the mystery of almost all of the brass instruments. He finds that the column of air in a cornet, a trombone, a horn, divides just as his violin string divided, and that the player, by managing his breath and his lips can produce the overtones one by one; he discovers that a plain tube, as a tallyho coach-horn, for example, can produce, not only a single tone, but several overtones, by symmetrical division of the column of air. Finally, still pursuing this branch of the subject, he discovers that the cornetist, the trombone-player, the horn-player, the trumpeter, holds not one tube, but seven, in his hands, when he is performing, that these tubes are all of different lengths and are made so by the three keys which (singly and in combination) cause each tube to be longer than the other, and that each tube gives its own series of overtones.

By this time our musician ought to be convinced that the study of acoustics is not a mere theoretical but an intensely practical one for him and for all musicians. Many further lines of study and investigation lie before the enthusiast. The mysteries of architectural acoustics will lead him to many strange discoveries about successes and failures in concert-halls and opera-houses. The tremendous force which lies latent in synchronism, or sympathetic vibration, is a very fascinating topic to pursue. The great discoveries of analysis and synthesis of tones upon which we are verging, the wonderful results of different shapes of vibrations, will be only a few of the many points of interest beyond those that we have enumerated, and he will find both practicality and poetry in the musical fairy-tales of Nature as revealed in the study of acoustics.